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The Developing Strategy of Green Energy Industry Cluster -A Case Study of the Solar Photoelectric Industry in Taiwan

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Abstract

It has become the international major and concerning issue for the energy shortage and environmental problem. The Cancun Agreement has continuous the carbon reduction from Kyoto Protocol program and stipulated the international greenhouse reduction in 2010. The global warming will be controlled between 1.5 degree and 2.0 degree. Until 2020, the countersigned convention countries should decrease carbon between 25% and 40% which is based on 1990 standard. The global countries dedicate to develop green energy industries to reach the goal.

The main motivation comes from the international community have done their best efforts to promote the solar photoelectric industry and reached USD2430 billion for green energy development in 2010. The solar energy industry development will become the hot industry in the future.

This Study uses Porter's Diamond model and a case study to analyze the developing strategy of Green Energy Industry Cluster, especially for the solar photoelectric industry in Taiwan. We follow the following 4 procedures to process this research:

1. Identify the local environmental advantage.
2. Upgrade the current solar industry technology development and transform the traditional industry.
3. Set up the personnel training and analysis lab system together.
4. Establish the government policy and subsidy reward.

We also use the questionnaire to collect the suggestion from the experienced experts/ scholars. The findings will suggest the proper strategy for developing solar energy industry as well as the future direction of government in solar energy industry cluster development.

Keywords: Green Energy, Industry Cluster, Solar Photoelectric Industry, Strategy.

1. Motivation and Objectives

1.1. Motivation

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The main motivation of this study comes from the fact: the 2010 global investment in green energy has reached 243 billion USD, and international community spares no effort to promote the development of the solar photoelectric industry [19]. For example, Japan plans to combine the fixed fuel cell and smart grid technology to develop the solar photoelectric industry with expected cumulative power installations up to 14GW in 2020. The US actively creates green energy-related job opportunities, provides solar energy companies with 1.85 billion USD of loan guarantee and is building solar power plants of world's top scale. Mainland China has proposed the national subsidy programs to award buildings integrated with solar photoelectric and rooftop solar power system to support solar power-related industries [18]. Other countries such as Germany, France, and Italy have set solar photoelectric development strategies and goals to greatly dedicate to the development of the solar photoelectric industry. In sum, the SPI is becoming a hot and emerging industry in the future. Regarding the promotion of green energy industry, if the government can establish more relevant policies to consider solar power industry (SPI) as an industry of developmental potentials in the future, it can help reshape industrial competitiveness and environmental protection policies as well as promote the industrial re-development.

1.2. Objectives

The development of solar photoelectric industry in Taiwan has a history of 10 years since the technological build-up and production capacity expansion stage starting from 2000, to the vertical industrial integration in 2006 and to the global division of labor and cross-sector integration in 2009. Major domestic manufacturers have been actively invested in the solar photoelectric industry. For example, Taiwan Semiconductor Manufacturing Company Limited (TSMC) invested in the research and development of solar cells, ADR_AU Optronics Corp. ADS (AUO) invested in the poly-silicon material factories in Japan the system plants in Germany, United Microelectronics Corp. (UMC) invested in solar photoelectric system plants. The 2010 solar cell production has grown by 250% with output value up to 193.8 NTD. The upstream and downstream supply chain of the solar photoelectric industry cluster has been gradually taking shape.

Hence, focusing on the development strategy of green energy industry cluster in Taiwan and the promotion of solar photoelectric industry in Taiwan as examples, the main purposes of this study include the following:

1) To explore strategies to promote the development of the solar energy industry and the industrial development status.
2) To analyze the feasibility of promoting the development of SPI from the cluster dimension.
3) To propose relevant comments on the strategies to promote the development of SPI.
4) To provide a reference for governmental policies promoting the development of SPI and follow-up relevant studies.

2. Literature Review

2.1. Definition of industry cluster

The industry cluster generally refers to a group of specialized manufacturers forming network relationships of complex operations. As a result, manufacturers in the cluster can lower production costs and transaction costs as well as get benefits, such as professional division of labor and know-how (Amin and Thrift, 1995). Porter (1990) defined the cluster as: "industries or companies with close links to gain complementary benefits through product or information flow". The geography economist Krugman (1991) pointed out that "the formation of cluster is based on certain economic activity. The clustering effect in a geographic region or the growth of the region in the global market attracts companies to form the industry cluster." Porter (1998) further elaborated on the industry cluster, defined it as "in a particular geographic area, relevant companies and corporate entities with complementarities and commonality interconnect with each other to form networks in scale ranging from a single city, state, nation or even to neighboring countries". "In particular, industrial cluster with advanced knowledge and technology can more easily attract new firms as well as strengthen local industrial strength and knowledge base (Maskell, 2001).

Industry cluster can be traced back the concept of city development (Morosini, 2004), which means a group of economic entities establish relationships due to geographic proximity to optimize their economic activities. Porter (1990) pointed out that the industry cluster can create competitive advantages. The proposed Diamond Model is regarded as the standard to implement industry cluster by a country through local planning (Kotval and Mullin, 1998). Industry clusters in different regions may be different by nature and inconsistent with each other in terms of internal industrial structure and development process. Each may have its distinctive developmental background and evolution process (Britton,2003;Boschma, 2004).

Observing from the high-tech industry development in the Silicon Valley of the US, the wine industry in the Napa Valley of California, and the development of the Italian leather fashion industry, the cluster effect of geographically related companies is one of the major factors for regional industrial development and industrial competitiveness enhancement. Hence, the theory of industry cluster will provide an important basis for the development of SPI.

2.2. Factor of industry clusters

In the book entitled "Competitive Advantage of Nations" published in 1990, Porter proposed the concept of the diamond system to illustrate the formation elements of the industry clusters by four interactively connected impact forces, which are Factor of Production, Demand Conditions, Related Industries and Supporting Industries, and Corporate Strategy, Structure and Competitors. The system is a mutually strengthening system and elements are mutually dependent. In addition to the four factors, Porter argued that Opportunities and Government should also be classified as the key elements of national competitive advantage. No country can merely rely on one single factor. The mutual development, cooperation, stimulus and enhancement of each element can keep the country progress continuously.

3. Methods and Design

After discussing the current development of SPI, its industrial structure by literature review, this study applied the Delphi Method to explore the relevant strategies for the future development and analyze the feasibility of the future development of the SPI.

The Delphi Method is also known as the expert judgment method. With Taiwan's export processing zone (EPZ) as the major research subjects, the method can be divided into two stages: 1) questionnaire survey: with anonymous and iterative feedback to provide participating scholars and researchers with opportunities of communicating professional knowledge to reduce personal bias and reach consensus; 2) statistical analysis of the feedbacks of scholars and experts to remove the randomly caused errors as well as the written reports and research conclusions provided by the researchers.

4. Results and Analysis

4.1. The first round/stage questionnaire statistics and analysis

After collecting the first round questionnaires, the results are represented by points from 5 (strongly), 4 (agree), 3 (on opinion), 2 (disagree), to 1 (strongly disagree). SPSS was used to analyze the results to obtain the average and mode as the screening standard of the questionnaire. Since 5 represents "strongly " and 4 represents "agree", the average number at 4 and the mode at 4 are selected as the screening standards. The items with average and mode number higher than 4 are retained. Those items with average or mode lower than 4 means that the significance of the strategy is regarded less important by the expert panel. Therefore, items with average or mode number lower than 4 are removed for analysis of the results.

1) Factor of production

Based on the statistical results, the average and mode numbers of most strategies in this dimension are higher than 4, indicating that most of the strategies in this dimension are regarded important by experts and scholars. The average number of the strategy "the wise exploitation of the advantage of relatively longer annual sunshine hours in southern Taiwan than the middle and northern Taiwan" is as high as 4.5 and the mode number is up to 5, indicating that experts and scholars are highly agreed with this strategy. In addition, the average number of the strategies including "the southern Taiwan's traffic infrastructure mainly consists of highway, railway, MRT, high-speed rail, the Kaohsiung Port and the Kaohsiung International Airport. However, the traffic connection is not good enough and should be improved", "to expand the Kaohsiung port to meet the international demands", "to expand the Kaohsiung International Airport to meet the internal demands" are lower than 4, indicating they are regarded less important.

2) Demand Conditions

Based on the statistical results, the average and mode number of the strategy of "to produce promotional effect of large scale international solar power exhibitions in Southern Taiwan through the visits of foreign guests to" are 4.09 and 4, respectively, the average and mode numbers of the strategy of "solar power-related manufacturers should understand the customer demands and improve their technology and R&D capabilities according to customer feedbacks" are 4.23 and 4 respectively, indicating that the two strategies in the dimension of demand conditions are regarded as relatively important. By comparison, the average number of the two strategies of "the stimulation of the domestic market demand for SPI in southern Taiwan can help the fast expansion, introduction of new technology and equipment and building of new plants of solar power-related manufacturers" and "to understand the demands on solar photoelectric equipments of the people in southern Taiwan and furthermore improve accordingly" are lower than 4, indicating they are regarded as not important at all.

3) Corporate Strategy, Structure and Competitors

Based on the statistical results, the average and mode numbers of most strategies are larger than 4. In particular, the average number of the strategy of "solar power-related manufacturers in the EPZ should actively win outsourcing orders from large companies in the US and Europe to improve production capacity utility rate" at 4.23, ranking the top. The average number of the strategy "manufacturers in the EPZ and industrial districts in Southern Taiwan have strong semi-conductor industrial basis to the development of solar power-related industries" is below 4, thus the item is removed.

4) Relevant Industries and Supporting Industries

Based on the statistical results, the average number and mode number of four strategies are larger than 4, the average number of the two strategies including "manufacturers relating to the development of SPI in the EPZ should strengthen ties with upstream material suppliers and downstream system providers", "manufacturers relating to the development of solar industry in the EPZ should work with the electronic manufacturers with global reputation and sales network to explore business channels in emerging markets" is 4.14, ranking highest in this dimension. The average number of the strategy "manufacturers relating to the development of SPI in the EPZ should work with the logistics industry to reduce logistics and transportation costs" is lower than 4 and thus the item is removed.

5) Opportunities

Based on the statistical results, the average and the mode number of two strategies are higher than 4, indicating they are regarded as relatively important. The average number of the strategy of "traditional heavy industries in southern Taiwan may transform to develop solar power-related industries in response to the decline of the industry to reduce the carbon tax problem of the future" is lower than 4 (removed).

6) Government

Based on the statistical results, the average and the mode number of most strategies are higher than 4, indicating that experts and scholars agree on the importance of the dimension. The average number of two strategies including "the central government should modify building regulations to compulsorily stipulate the use of BIPV to achieve the solar photoelectric application effect" and "Incorporation of the power and opinion of major local enterprises in Kaohsiung such as Motech and Delta regarding the incentives and opinions for the development of the SPI" is lower than 4, and thus the question item is removed.

The ANOVA analysis results of the first round questionnaire suggested that, only three question items are significant, indicating experts and scholars in different fields have different opinions about three questionnaire items. The three items are shown in Table 4.1. As seen, experts and scholars of different fields have significant variance in recognition of the No. 2 question in the dimension of Factor of Production, No. 3 of the Opportunities dimension and the No. 3 of the government dimension. The post-event test revealed that, the private sector and academic institutions have higher level of recognition than research institutions regarding the questionnaire item of "wise use of the advantage of relatively wider land in southern Taiwan than the middle and northern Taiwan". The recognition by the academic institutions about the questionnaire items including "traditional heavy industries in Southern Taiwan (such as ChinaSteel, CPC) may transform to develop solar power-related industries in response to the decline of the industry to reduce the carbon tax problem of the future" and "to improve the environmental protection awareness of the residents in southern Taiwan through publicity of energy depletion by media or marketing activities of the EPZ" is higher than that of the research institutions.

Table 4.1 The first-round ANOVA Test

Question Item		Sum of Squares	DOF	Average Square	F-test	Significance (P-value)	Scheffe-test
Factor of Production No.2	Inter-group	5.61	3	1.87	5.46	0.008	Non-government Study
	Intra-group	6.21	18	0.34			Academic Study
	Sum	11.82	21				
Opportunities No. 3	Inter-group	6.56	3	2.17	4.61	0.012	Academic Study
	Intra-group	8.46	18	0.47			
	Sum	14.84	21				
Government No. 3	Inter-group	2.02	3	0.67	2.83	0.068	Academic Study
	Intra-group	4.38	18	0.24			
	Sum	6.93	21				

Source: compiled by this study

4.2. The second round questionnaire statistics and analysis

The two Delphi Method questionnaires used in this study take data from same sample source. Hence, this study used the pairwise sample t-test analysis to analyze the average number difference of the two samples to confirm whether the question items of the two questionnaires are stable.

Assuming that the average number of the two samples are $\mu 1$ and $\mu 2$ respectively, $\begin{cases} H0: \mu 1 - \mu 2 = 0 \\ H1: \mu 1 - \mu 2 \neq 0 \end{cases}$

SPSS was used for the pairwise sample t-test analysis. The results of the pairwise samples are shown in the appendix where the differences between average numbers refer to the average number differences of two pairwise samples. The "95 % confidence interval of the difference" means: when $\mu 1 = \mu 2$, under the limit of 95% confidence interval, if the upper and lower limits of the obtained values are around 0, namely, 0 falls into the upper and lower limits, it represents $\mu 1 = \mu 2$ without significant differences and is acceptable; otherwise, it is rejected. The "Significance" of the t-testing results is the P value of the pairwise comparison, and having another indicator to test the significance or not. If P values < 0.05, the averages of the two pairwise samples have significant differences, thus H0 is rejected; if P value > 0.05, it means the averages of two pairwise samples have no significant differences, and thus H0 is accepted. Ten of the original 45 question items of the first questionnaire are removed. This study conducted the pairwise sample t-test of the 35 items, and 33 items have significance with P value larger than 0.05, therefore, H0 is accepted, indicating the averages of the pairwise samples have no significant differences, in other words, the opinions of the two rounds of questionnaires are stable.

The significance level of the No. 4 item of the dimension of relevant industries and supporting industries "manufacturers relating to the development of SPI in the EPZ should work with Taiwan's electronic manufacturers with global reputation and sales network to explore business channels in emerging markets" and the No. 15 item of the dimension of government "Governmental agencies should assist the university-industry institutions in the investment in strategic research and development and promote cross-industry alliance based on the platform of the electronics industry for innovative product applications" are at 0.02, being lower than 0.05 and suggesting significant differences.

The ANVOA analysis results of the additional strategies of the second round questionnaire are shown in Table 4.2. As seen, only one additional strategy has significance, indicating that experts of different fields have different level of recognition. The strategy is "the government directly demands by decree that new buildings should have certificate to use alternative energies by certain proportion. It can be learnt from Table 4.2, its P-value＝0.015, suggesting the significance level of the strategy. The post-event test suggested that private firms have higher level of recognition than governmental officials, believing the strategy is important to the development of the solar photoelectric industry in southern Taiwan.

Table 4.2 The second round ANOVA-test of newly added strategies by experts and scholars

Question Item		Sum of Squares	DOF	Average Square	F-test	Significance (P-value)	Scheffe-test
Factor of Production No. 1	Inter-group	1.25	3	0.42	0.64	0.6	
	Intra-group	11.71	18	0.65			
	Sum	12.96	21				
Supported Industry No. 1	Inter-group	0.22	3	0.07	0.55	0.657	
	Intra-group	2.38	18	0.13			
	Sum	2.60	21				
Opportunities No. 1	Inter-group	0.49	3	0.16	0.55	0.66	
	Intra-group	5.38	18	0.30			
	Sum	5.87	21				
Government No. 1	Inter-group	4.02	3	1.34	4.60	0.015	Non-government>Government
	Intra-group	5.25	18	0.29			
	Sum	9.27	21				
Government No. 2	Inter-group	2.46	3	0.82	1.73	0.196	
	Intra-group	8.50	18	0.47			
	Sum	10.96	21				
Government No. 3	Inter-group	0.71	3	0.24	0.995	0.418	
	Intra-group	4.25	18	0.24			
	Sum	4.96	21				
Government No. 4	Inter-group	2.03	3	0.68	1.92	0.162	
	Intra-group	6.33	18	0.35			
	Sum	8.36	21				
Government No. 5	Inter-group	1.11	3	0.37	0.99	0.419	
	Intra-group	6.71	18	0.37			
	Sum	7.82	21				
Government No. 6	Inter-group	0.79	3	0.26	0.91	0.455	
	Intra-group	5.21	18	0.29			
	Sum	6.00	21				

Source: compiled by this study

5. Conclusions and Recommendations

5.1. Conclusions

This study applied the Delphi Method to obtain the opinions of experts who have conducted in-depth study and practical experience in the field of solar power. This study obtained consensus of experts and scholars by feedbacks and statistical analysis to summarize the strategies for the development of SPI. According the rerult, this study proposed strategies and suggestions for the promotion of the SPI for the reference of relevant organizations and follow-up researches.

Regarding the major strategies to promote the development of the SPI in southern Taiwan, according to the above statistical analysis, this study found that the following major strategies are considered as feasible by experts and scholars for the development of the SPI in southern Taiwan after deleting items of inconsistent opinions (quarter potentiometer >0 and variance coefficient ≧0.5) and items of low importance (concentration trend<80 %): the average number of the two strategies including "Establish a solar power testing international certification centre in southern Taiwan" and "the central government works with Taiwan Power Company to establish and perfect the solar power electricity purchase regime" are 4.45, ranking number one in terms of significance. Moreover, SPI cluster may be developed by utilizing the upstream and middle supply chain with the infrastructure environmental advantages for the development of downstream application systems.

5.2. Research recommendations

The study found that, according to the statistical data of the Central Weather Bureau, the average annual temperature in southern Taiwan is above 25 degrees. With the characteristic of ample sunshine in all seasons, the annual sunshine hours in southern Taiwan is 2523 hours, an average of about 7 hours a day, ranking the highest in Taiwan. The ample sunshine is suitable for the application and development of the SPI. Although there are industry clusters in Tao-Chu-Miao region, they are mainly manufacturing firms. There are also SPI players in the Southern Taiwan Science Park and the export processing zone in Pingtung, and solar power pilot application communities and pilot plants in southern area. Therefore, with the help of the upstream and middle supply chains surrounding the export processing region, as well as the neighboring environmental advantages for the development of downstream applications, the solar power related industries can be developed in southern Taiwan. The study recommendations as follows:

1) Use the superior infrastructure and industry clusters

Excellent infrastructure and geographic conditions are the primary conditions for the development of SPI. Integration with industry clusters can be the natural niche for the rapid development of the industry.

a) Ample sunshine is a great niche for the development of the solar energy industry.
b) The advantageous strategy to attract leading manufacturers by cluster effect can promote the formation of the SPI cluster.
c) Help manufacturers to acquire vast hinterland, thus allowing manufacturers of the upstream, middle and downstream of the supply chain to develop concurrently in the industry cluster.

2) Improvement of the existing solar power industrial R&D capabilities and the transition of traditional industries.

In addition to the active government support, the improvement of the technological and development capabilities of the solar power companies is considerably important. In the long run, raw material supply should be controlled and the integration with upstream raw materials and downstream system applications should be strengthened to speed up the building and integration of supply chain to enhance industrial competitiveness. Solar power-related manufacturers should understand customer demand types and improve their technology and development capabilities by absorbing feedbacks. In addition, the product quality should be strictly controlled to build up international reputation by certification mechanisms of solar power system or product developed by research institutions or governmental agencies.

3) Establish mechanisms for talent cultivation and laboratories

a) Establish mechanisms for cultivating talents:

Professional are important in the development of an industry. The SPI is a new industry in Taiwan and abroad, and thus talent cultivation is essential.

b) The assistance and incubation of research and development institutions:

With Europe's largest solar power research center, Fraunhofer Institute for Solar Energy System (ISE), Freiburg in Germany has established a solar power information centre. Through successful technical transfer and incubation, many manufacturers have established plants in the region to form the complete industry cluster. Hence, specific research themes can attract relevant research institutions to improve the industrial park's capabilities in terms of research, design and system verification, which is essential to promoting the recognition and trust of the verification results of the industrial park of the industry.

c) Establish the solar energy testing international certification centre:

At present, manufacturers often face various problems arising from the testing of solar photoelectric products including high testing costs, long testing time, lack of improvement of failure items tested by foreign institutions. If products can be tested and verified in international certification laboratories in Taiwan, the above difficulties may be overcome to save recognition time and costs for manufacturers in the Asia-Pacific region. At the same time, testing can improve the quality of domestic products to explore the foreign markets and establish national testing mechanism to ensure the power generation effectiveness of the domestic solar photoelectric systems.

4) Governmental policies and subsidy incentives

Government is often the promoter of local industrial development. In addition to policy making, it plays the role of promoting and implementation. From the dimension of power generation costs of the solar photoelectric system, governmental subsidy policies are the biggest factor for the development of the solar photoelectric industry. Japan, Germany and the US are very successfully in the development of the solar photoelectric industry due to the active promotion and implementation of subsidies by their governments. Hence, this paper suggests: a) establish incentive systems; b) establish related laws; c) model applications and implementations;d4) improve the public awareness of solar power related products and equipments. The governmental policies and subsidy incentives should be planned for solar photoelectric model communities and pilot fields in the form of industry cluster for the development of the solar photoelectric industry.

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